**900 MHz NOI Proposed Rebanding**

**Engineering Report**

**900 MHz LMR Spectrum**
**Issues with Repurposing**

**Prepared For:**

**Florida Power & Light / NextEra**


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# 1 Introduction

The FCC issued a Notice of Inquiry (FCC 17-108) in WT Docket No. 17-200 - *Review of the Commission's Rules Governing the 896-901/935-940 MHz Band* to seek comments on how best to use this 5 x 5 MHz block of spectrum.

For decades, the 900 MHz band has been used by Critical Infrastructure Industry (CII) and other Land Mobile Radio users for critical voice and narrowband (NB) data to support the primary operations of users such as utilities. Reconfiguration of this 900 MHz spectrum block, as being considered by the FCC, will have a number of negative significant impacts on existing users of the spectrum.

In its initial proposal to the FCC[1], Pacific Data Vision and Enterprise Wireless Alliance (collectively, PDV), proposed to reconfigure and partition the 896-901/935-940 MHz band ("900 MHz band") into a 2 x 2 MHz and a 3 x 3 MHz block of spectrum and allow PEBB (Private Enterprise Broadband) LTE operations in the 3 x 3 MHz. The proposed PEBB 3 x 3 MHz block would occupy the 898 MHz to 901 MHz and 937 to 940 MHz sub bands, while a 2 x 2 MHz block would be allocated to the 896 to 898 MHz and 896 to 898 MHz sub bands.

The number of narrowband (12.5 kHz) radio channels available to the Business/Industrial/Land Transportation (B/ILT) and CII users would be 160 channels in the 2 x 2 MHz sub-band. This is quite a substantial reduction of the 400 channels available in the present 5 x 5 MHz band.

PDV's initial 3 x 3 MHz and the 2 x 2 MHz B/ILT-CII 900 MHz sub-band allocation proposal is shown in the figure below.

[1] Review of the Commission's Rules Governing the 896-901/935-940 MHz Band-WT Docket No. 17-200, Adopted August 4, 2017

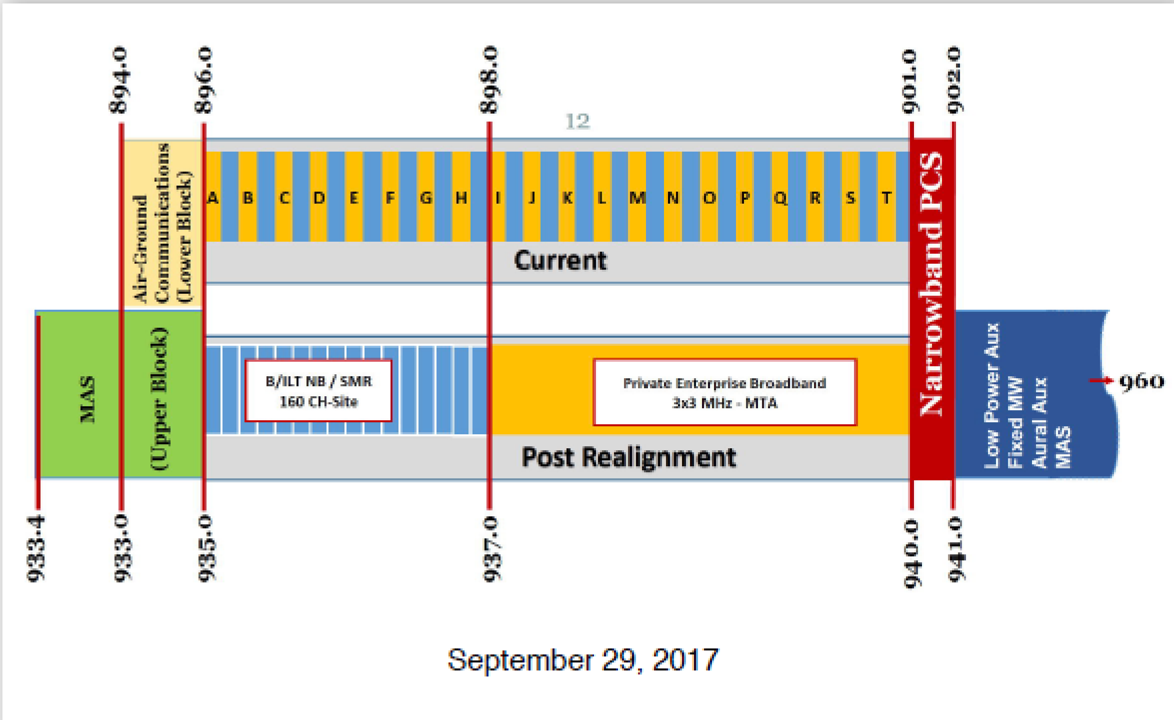


Figure 1: PDV Initial Proposed Band Allocation

PDV's second proposal to the FCC was modified by shifting its 3x3 MHz PEBB channel block 400 KHz down from the 901 MHz band edge. [2] The motivation for the sub band shift was to provide a guard band between the Sensus, America's Inc. (Sensus) operations in the 901 to 902 and 940 to 941 MHz bands. Sensus is an automated metering infrastructure (AMI) manufacturer that has thousands of fixed metering units (endpoints) and several collections points (base stations) used by many utilities throughout the United States.

[2] Review of the Commission's Rules Governing - WT Docket No. 17-200 the 896-901/935-940 MHz Band, May 1, 2018

PDV's newest proposed 3 x 3 MHz sub-band would exist between 936.6 to 939.6 MHz. PDV's proposed spectrum repurposing is shown in the figure below.

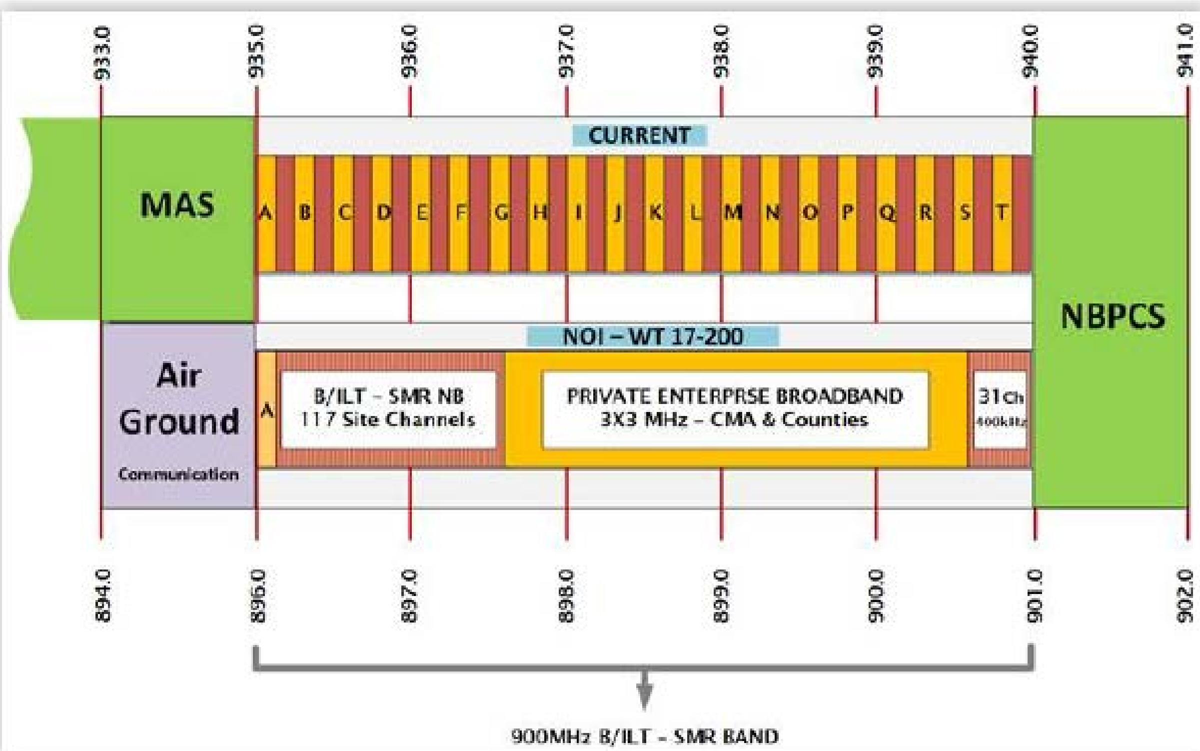


Figure 2: PDV Revised Sub-band Allocation

It is noted that in PDV's latest proposal, the 2 x 2 MHz sub-band allocation for the B/ILT-CII users have been reduced to 1.85 x 1.85 MHz. The reduction in bandwidth is because in the PDV proposal, they have set aside 10 channels (125 kHz) that would be assigned to the Association of American Railroads (AAR) (see sub-band A) in Figure 2 above. Under the revised PDV proposal, those 10 contiguous channels would be set aside for AAR in place of the 6 non-contiguous channels currently assigned to AAR (*see* call sign WPSF894). In total, the revised PDV proposal results in a further reduction of narrowband channels from the 400 channels available today to 160 channels under the initial PDV proposal, and finally to 148 channels under the present revised PDV proposal.

The purpose of this engineering report is to further analyze the issues raised by Florida Power & Light in its November 1, 2017 “Reply Comments of NextEra Energy, Inc.” by adding observations made, experience gained, and investigation results arrived at by Gillespie, Prudhon & Associates, Inc. (GP&A). GP&A has over 38 years of experience providing telecommunications engineering services to CII clients.

## 2 Executive Summary

The findings of this report show that there are major concerns regarding PDV's PEBB proposal for the 900 MHz band. In this document we have explored the technical and basic economic concerns of PDV's 900 MHz PEBB proposal. These concerns are:

1. Loss of coverage due to:
    a. Compacting of the entire B/ILT-CII 900 MHz users into a 1.85 x 1.85 MHz sub band in the 900 MHz band.
    b. Interference from adjacent short spaced NB 900 MHz channel assignments
    c. OOBE impacts into base and mobile receivers from PEBB LTE transmitters
    d. Geographical limitations on co-channel reuse
    e. Insufficient interference protection threshold rules.
    f. Lack of guard band between LTE and NB 900 MHz operations
2. Cost to FPL

FPL believes that the proposed PEBB LTE technology is not a good choice for the control, operations and maintenance of their energy transmission and distribution grid network. Most of FPL's remote automated, monitoring and control needs can be met with low bandwidth and low speed real time data communications networks such as point-to-multi-point (PMP) radio and Field Area Network (FAN) radio systems. These radios can operate in the 400, 700, and 900 MHz bands using channel assignments between 12.5 kHz to 100 kHz and deliver between 48 to 480 kbps data rates, which more than meets FPL's Distribution Automation (DA) requirements. The creation of a 3 x 3 MHz sub band for the implementation of an LTE network is not necessary in the 900 MHz band.

FPL has designed a 900 MHz trunked radio system that has been optimized to maximize coverage and reliability and keep operating costs down. FPL's existing 900

MHz base station sites are maintained to a maximum of 2 dB of average receiver sensitivity degradation wherever possible. FPL is very proactive about identifying interfering noise sources by routinely measuring receiver sensitivity degradation, performing maintenance, and identifying and removing noise sources at their sites.

FPL presently measures the environmental site noise and receiver sensitivity degradation on a monthly basis in order to identify radio sources that cause a degradation in receiver sensitivity and service area. FPL corrects any issues that degrade the receiver sensitivity by more than 1-2 dB. This requirement has been respected by cellular carriers operating in adjacent bands and corrected when those wireless carriers impact FPL systems.

The negative impacts that the proposed PEBB LTE network will have on FPL's 900 MHz push-to-talk radio network identified in this document are numerous and quite possibly could risk lives and cause delays in response by limiting FPL's capability to respond in emergency situations wherever there are RF coverage issues in distressed areas.

In addition, there are issues with the PEBB proposed rule changes that do not provide adequate protection levels from interference generated by PEBB LTE transmitters. FPL's existing coverage is designed to provide a Delivered Audio Quality (DAQ) of 3.4, 95% of the time.[3] PDV's proposed rule change would only provide interference protection for area's covered with a receive signal level of -98 dBm for mobile and -95 dBm for portables. The protection levels provided to 800 MHz Public Safety radio systems are -104 dBm for mobiles and -101 dBm for portables,[4] which would be more appropriate for protecting CII radio systems.

[3] 900 MHz coverage is designed for a DAQ 3.4 using -110 dBm signal (50%L, 95%T)
[4] 47 C.F.R. §90.672.

In the 700 MHz and 800 MHz bands, where LTE has been implemented, the adjacent users enjoy a guard band of approximately 1 MHz from the edges of the LTE signal. Because of complaints from Sensus America, Inc. that operates data radio equipment in the 901-902 / 940-941 MHz bands, PDV modified its 3 x 3 MHz band proposal and shifted its band edges down 400 kHz from the Sensus occupied bands. This helps the Sensus radios, but the B/ILT-CII channels have only a 150 kHz transition band. With only 150 kHz there is not enough separation bandwidth (guard band) to implement an external filter should there be a severe case of interference from the PEBB LTE transmitter out of band emissions (OOBE). If PDV were to limit the size of the LTE transmitter to an occupied bandwidth of 1.4 MHz, then a 0.960 MHz guard band could be realized.

The proposed PEBB LTE network will require FPL to redesign its 900 MHz radio to operate in a higher noise and interference environment. Most of FPL's base station sites will lose coverage area as compared to the existing sites FPL operations today. If the PEBB LTE systems are installed and FPL and other B/ILT-CII users are moved to the smaller sub band, new base station sites will be needed to recapture lost coverage area. The estimated cost to recapture coverage is significant. Presumably, other large B/ILT-CII users of the 900 MHz band that have large PTT radio networks will have similar costs that will have to be financed by the PEBB who constructs LTE system.

## 3 Compaction of B/ILT and CII Narrowband Radio into a 1.85x 1.85 MHz Spectrum

Compacting all narrowband operations into a 1.85 x 1.85 MHz block of spectrum will reduce the "channel pool" and frequency separation between adjacent channels. Compacting will also reduce the physical separation between co-channel stations. The ultimate result will be an increase in the likelihood of interference from adjacent channel operations within the B/ILT-CII user community. To limit co-channel interference the B/ILT-CII community will need to reduce power and use short space design techniques. Both of these remedies will require an increase in the number of base station sites in order to recapture existing service area.

In general, the wider 5x5 MHz spectrum band has allowed assignment of RF channels with minimal insertion loss in the antenna combiner units (ACU) subsystems. FPL has kept the ACU losses down because the channel assignments for any given ACU range from 162.5 to 1,000 KHz between channel assignments. Reassignment to a narrower allocation will require additional channel assignments with less frequency separation between channels, thus higher ACU losses are expected.

The addition of new base station sites will require new channel assignments for all incumbents with operations in overlapping geographical areas. It is expected, under these conditions, that users will experience an elevation of the system RF noise floor and interference from other users operating in this band as they move to change their channel plans in order to comply with FCC mandated contours and accommodate this reduction of spectrum.

In the state of Florida, FPL's existing 900 MHz radio system has 67 trunked radio base station sites, 17 control stations for monitor and control, 35 dispatching locations, and over 5,200 mobile and portable subscriber radio units. These sites are indicated by the red circles in the figure below, while PDV sites are indicated by the blue circles, and all other licensees' sites are indicated by the yellow circles.

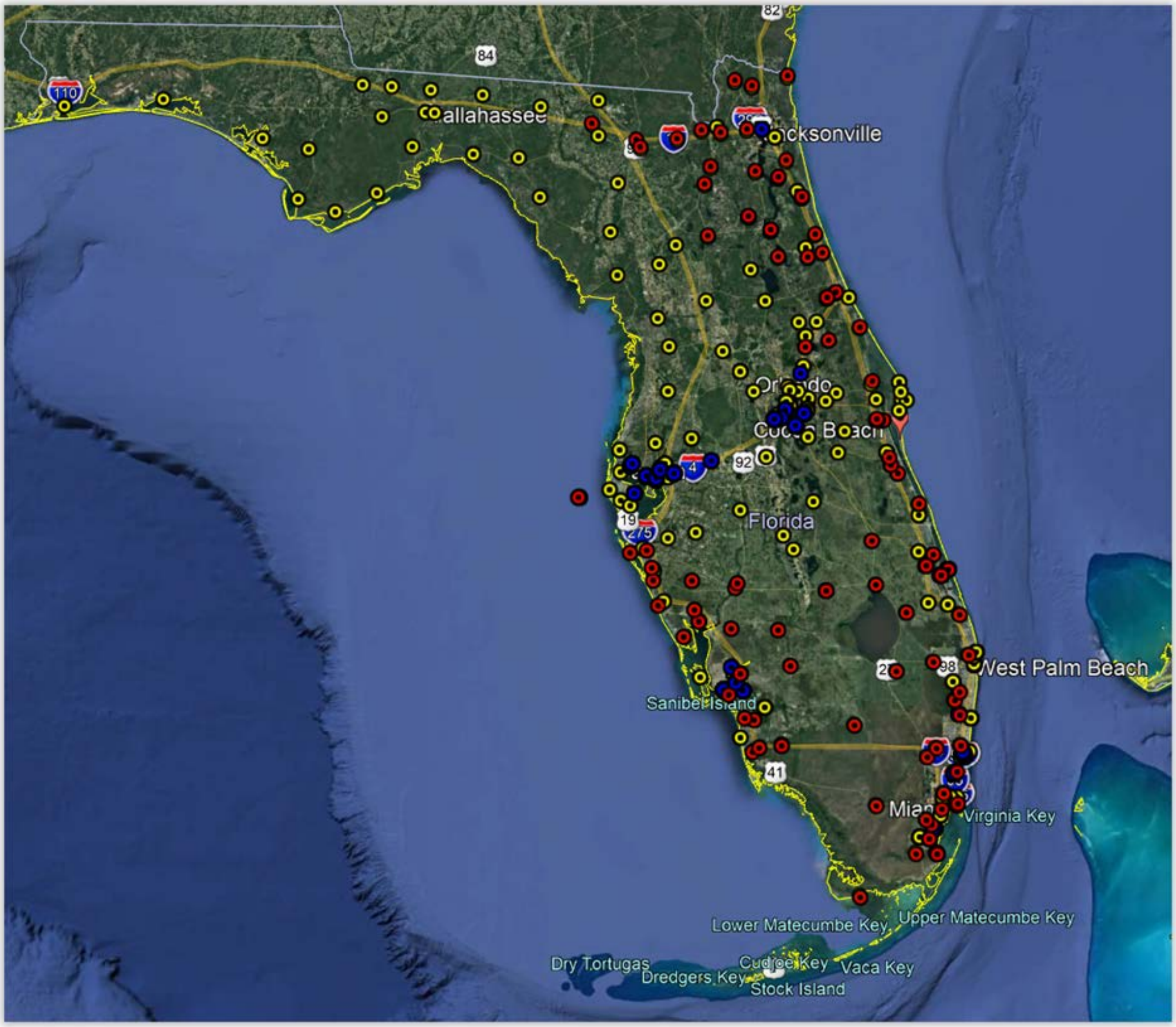


Figure 3 FPL Sites in Florida

The number of existing 900 MHz base station radio transmitters operating at FPL's 67 radio sites in Florida are shown in the Table below: 65% of these stations are in the proposed 3x3 MHz allocation.

Table 1: Number of Existing FPL 900 MHz Base Station Transmitters

| **FPL RADIO SYSTEM TYPE** | **Number of Existing 900 MHz Base Station Transmitters** | | | **TOTAL** |
|---|---|---|---|---|
| | **B/ILT-CII Lower Sub-Band** | **3x3 MHz PEBB Sub-Band** | **B/ILT-CII Upper Sub-Band** | |
| | **935.1375-936.6 MHz** | **936.6-939.60 MHz** | **939.6-939.9875 MHz** | |
| **TOTAL NO. OF BASE RADIO TX'S** | 113[5] | 280[6] | 38 | **431** |

PDV's proposed rule change would require that FPL relocate its radios that occupy the proposed 3x3 MHz band over to the 1.85 x 1.85 MHz band. This relocation would require that FPL relocate the 280 base station transmitters in Table 1 above into the new 1.85 x 1.85 MHz sub-band.

Reducing the number of available channels is not just a process of moving (retuning) channels from the 3x3 MHz block to the 1.85 x 1.85 MHz block of spectrum. It requires a complete re-engineering of the frequency plan for the entire 1.85 x 1.85 MHz block to optimize the spacing and repositioning of the required channels in the reduced spectrum block.

In addition to the relocation of FPL's channels from the 3x3 MHz band, more base station transmitters are necessary to recapture the existing coverage area lost due to a rise in the noise floor. This rise in the noise floor is caused by the compaction (overcrowding) of FPL and other B/ILT and CII users in the 1.85 x 1.85 MHz band, OOBE and receiver blocking from the PEBB operations.

[5] The total number of FPL's channels that lie within the proposed B/ILT-CII band is calculated from the B/ILT CII Lower Sub-Band and the G/ILT-CII Upper Sub-Band, which is 113 + 38 = 151 channels.
[6] The total number FPL's channels that lie within the proposed PEBB 3x3 MHz band is 280 channels.

The re-engineering effort would require modifications of RF antennas and combiner subsystems at existing sites. Compressing all of the B/ILT-CII users into a narrower band allotment will require the short spacing of sites, extensive re-use of co-channel assignments, and reduced spacing of base station frequencies and will cause systems to operate with much higher noise floors. All of these factors will reduce the coverage area and increase the number of base stations, complexity, and cost to redesign, construct and operate narrowband radio systems. Impacts to narrowband systems will be most noticed in the fringes of coverage areas, where systems are most susceptible to harmful interference.

Compacting the spectrum will also lead to increased co-channel and adjacent-channel pairing related interference and transmitter power loss due to tighter channel spacing in the transmit combiner. Tighter channel spacing also causes mobile/portable radio receiver sensitivity degradation. The impacts of intra-system interference caused by 1.85 x 1.85 MHz compaction would happen independently without the introduction of PEBB operations in the 3x3 MHz band. The addition of PEBB operations, however, will further aggravate LMR operations when mobiles and portables travel past or are operated near LTE transmitter sites.

A coverage analysis (See Appendix A) was done to determine the loss of FPL's service area due to the relocation and the interference caused by the proposed PEBB system operating in the adjacent 3x3 MHz band.

From the coverage analysis, it was determined that FPL will need to add 45 new short spaced sites equipped with five (5) base station transceivers each, in addition to the 67 existing sites to recover the service area lost due to PEBB interference. Eleven new sites with 5 transceivers are added for mitigation of adjacent channel interference from other NB operations. This would add a total of 56 new base station sites and 280 base stations transceivers to FPL's existing 900 MHz radio network.

To estimate the amount of required channels in the 1.85 x 1.85 MHz for FPL's present coverage requirements, we note the following facts and assumptions:

1. There are a total of 148 channels available in the proposed 1.85 x 1.85 MHz 900 MHz sub-band.

2. FPL's present system uses 431 base station transmitters at 67 locations in the state of Florida. When relocated to the 1.85 x 1.85 MHz band, a 5 channel trunked radio network will be required in order to recapture coverage due to the impacts caused by compaction and interference.

3. FPL has estimated the total number of sites and channels required to sustain their existing coverage in Florida to be:

Table 2: 900 MHz Channels Required for FPL in the State of Florida

| DESCRIPTION | NO. OF SITES | NO. OF RF CHANNELS PER SITE | NO. OF RF CHANNELS |
|---|---|---|---|
| No. of Existing FPL sites in Florida | 67 | 5 | 335 |
| Estimated Number of New Sites Required to Recapture Service Area | 45[7] | 5 | 225 |
| Estimated Number of New Sites to Mitigate Adjacent Channel Interference issues due to short spacing[8] | 11 | 5 | 55 |
| **TOTAL** | **123** | | **615** |

To estimate the number of available 900 MHz channels within the state of Florida that can exist within a 1.85 x 1.85 MHz sub-band, we take the 148 total available channels in the PDV proposal and multiply by an estimated channel re-use ratio. The channel re-

[7] The number of new base stations is based on the reduction of coverage in the coverage analysis in Appendix A due to rise in the noise floor and the requirement to design for reliable coverage at the protection level of -98 dBm for mobiles and -95 dBm for portables.
[8] It is assumed that because many of the existing and new sites will need to be short spaced with FPL's sites as well as the other B/ILT-CII user sites. Short-spacing will cause additional loss of coverage, requiring more sites to recapture service area.

use rate is estimated to be approximately 9 times[9] using a co-channel site separation distance of 100 miles. This means that a maximum number of channels the 1.85 x 1.85 MHz sub-band can accommodate in the state of Florida is 1,332 channels.[10] For FPL to recapture their existing coverage, we expect that FPL will need 46% of the available number of narrowband channels for Florida.

FPL is concerned that conversion of the entire B/ILT-CII community over to the narrow 900 MHz sub-band will require nearly all users to redesign their radio systems using short space distances less than 70 miles. This estimate doesn't include the future channel requirements of FPL's or the other B/ILT-CII users in Florida.

Relocating FPL and the B/ILT-CII community of 900 MHz users from the 5x5 MHz band into the 1.85 x 1.85 MHz band may not be feasible.

Compaction of channels will result in significant spectrum shortages with significantly more short spacing of co-channel and adjacent-channel base stations. The extent of required short spacing would exceed the limits of the current FCC rules[11] governing short spacing between entities. This close spacing will increase the incidence of both self-interference and interference from other operators:

- Reducing the available bandwidth for incumbent narrowband users will increase transmitter noise levels at sites where narrowband users are co-located in this band. Increased transmitter site noise will increase receiver degradation.

[9] It is assumed that for the state of Florida, given its unique shape, the number of times a channel can be reused if the average distance between co-channel stations is 100 miles is 9 times. If the distance between co-channel stations is 70 miles, the number of times a channel can be re-used in the state of Florida is 14 times. In most applications, the majority of the FPL co-channel assignments are assumed to be 100 miles with only a few co-channel stations separated somewhere between 70 to 100+ miles.
[10] Total number of channels in the 1.85 x 1.85 MHz band in Florida = 148 x 9 = 1,332.
[11] 47 C.F.R. §90.621.

- Wideband applications in the adjacent 3x3 MHz band allocation will contribute to additional receiver sensitivity degradation in the adjacent narrowband segment. This will further impact the incumbents' operating area for each site thus requiring more spectrum where a shortage will already exist.

- The compression of multiple narrowband users into the 1.85 x 1.85 MHz spectrum will leave existing narrowband systems without the ability to expand their networks. Degraded performance occurs due to increased noise levels which will result in reduced coverage, lower audio quality, and lower communication reliability. Going forward, this will be a barrier to making cost effective investments in narrowband 900 MHz mobile communications systems.

## 4 Guard Band

The use of narrowband systems within the current 5x5 MHz band requires a guard band on the perimeter of the band where cellular systems exist. The introduction of a LTE system within the 5x5 MHz band we believe will require a guard band to reduce harmful LTE emissions into narrowband systems, similar to the protection provided to Sensus America, Inc.[12] and the 800 MHz Public Safety Spectrum Trust (PSST) bands. The continuous operational nature of a broadband LTE signal in the 3x3 MHz spectrum block will likely cause fluctuating but persistent interference unlike the narrowband systems that have been more sporadic in their transmissions.

In contrast to 700/800 MHz bands that both have broadband adjacencies and guard bands, no guard band has been included in the PEBB proposed 900 MHz plan, except for the 901-902 MHz band.

Proponents of the realignment argue that guard bands are an inefficient utilization of spectrum. However, guard bands are a necessary mechanism to protect operations in adjacent bands particularly when the adjacent band operators deploy dissimilar technology.

Interference from neighboring allocations can be separated into three primary mechanisms that are independent of technology:

(1) Transmitters generally emit noise-like energy outside their allocated bandwidth. This energy may be superimposed on the selected bandwidth of a

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[12] See WT Docket No. 17-200, In the Matter of Review of the Commission's Rules Governing the 896-901/935-940 MHz Band FURTHER COMMENTS OF ENTERPRISE WIRELESS ALLIANCE AND PDVWIRELESS, INC., May 1, 2018. See id., page 3: "Shift the PEBB allocation down 400 kHz to 897.600-900.600/936.600-939.600. This will move the broadband allocation away from adjacent 901/940 MHz Narrowband PCS ("NPCS") systems operated by customers of Sensus America, Inc. ("Sensus"). This shift also will create an upper and lower PLMR narrowband segment, thereby allowing greater separation between co-located frequencies in narrowband systems."

victim receiver in a nearby band, thereby reducing the signal-to-noise ratio. Accordingly, the performance of the communication system is reduced.

(2) No receiver in practice can capture its target frequency band with perfect selectivity. Instead receiver performance is based on economic and performance tradeoffs. Any receiver subject to sufficient interference energy outside its selection bandwidth, particularly when interference is adjacent in frequency, will be degraded in its ability to capture the desired signal. FPL's 900 MHz base station receivers use extensive filtering to protect their radio reception from adjacent channel interference. However, in the case of in-band interference caused by out-of-band-energy from adjacent PEBB transmitters the only remedies available to limit interference are distance, transmitter out-of-band-energy limits and frequency separation provided by a guard band.

(3) External components to a transmitter can re-radiate transmitter energy that appears as noise in the receiver bandwidth. This mechanism usually results from defective components at a site location or from transmitters[13] with poor reverse intermodulation performance. Defective site components include any element of a site that exhibits a non-linear response to incident RF energy. Examples include rusty bolts, loose connectors, corroded connectors, poorly specified connectors, antenna elements, and others. These elements through a non-linear response to incident RF energy re-radiate energy that may include harmonics and intermodulation products of nearby transmitters. Resulting energy within a victim receiver's bandwidth reduces communication system performance as described in (1) above. Transmitters that are not properly protected with isolators from reverse intermodulation may also re-radiate energy as harmonics and intermodulation products just as the defective elements do. CII narrowband PMLR radio systems, as part of the normal design process,

[13] The offending transmitter may not be the most adjacent.

incorporate dual stage transmitter isolators and external filters to control reverse intermodulation from occurring. If the PEBB radio systems do not use the same design practices, then they could become a source of reverse intermodulation.

Transmitter Out-Of-Band-Energy (OOBE) – OOBE is generally expected to add to a victim receiver noise floor. Transmitters tend to have lower out-of-band emissions as frequency separation from the main signal increases. However, the shape of out-of-band emissions is highly dependent on high power amplifier linearization techniques employed and on the selectivity of output filtering. Some linearization techniques provide a spectrum that falls off rapidly, but presents a significant noise pedestal that is much wider than the desired signal. High selective filtering may be used to lower such out-of-band emissions, but only if the transition bandwidths between a transmitter and victim receiver are sufficient.

Specifically, for the 900 MHz band and a 3 MHz LTE signal, the LTE desired bandwidth is 2.7 MHz, which leaves 150-kHz on either side before reaching the band edges. The implementation of a one (1) MHz guard band would allow approximately eight times the transition width (1.15 MHz) before reaching the next band. However, introducing a guard band for a 3.0 MHz LTE channel would only take more channels away from the incumbent B/ILT-CII users in the adjacent 1.85 x 1.85 MHz band; therefore, a guard band is not possible for a 3.0 MHz LTE channel.

Implementation constraints on transmitters are easier with a guard band when controlling OOBE. More importantly, rules are set to minimize harmful interference, but not for worst case conditions. Protection thresholds in practice provide mitigation for harmful interference where it is identified as a problem. Harmful interference locations will be found and some will involve worst case conditions. Several interference mitigation techniques can be deployed, but filtering is severely limited by the very small 150 kHz transition range. Other mitigation methods like lowering transmitter power, antenna change, and moving a site have much more difficult tradeoffs.

It should be noted that the PEBB proponents modified their original 3x3 MHz channel proposal to reside within part of the spectrum originally proposed as a 2 x 2 MHz allotment proposed for the B/ILT-CII users. This change in the 3 x 3 MHz allotment was sought in order to provide a 550[14] kHz guard band for users in the 901-902 MHz band. No guard band is proposed for the protection of B/ILT-CII users, as previously shown in Figure 2.

Because the proposed B/ILT-CII 1.85 x 1.85 MHz spectrum resides above and below the proposed 3x3 MHz PEBB band, the OOBE from the LTE-PEBB transmitters will be impacting the B/ILT-CII narrow band channels in the lower and upper portion of the proposed 1.85 x 1.85 MHz band allotment. If the PEBB LTE transmitters deploy a 3.0 MHz channel bandwidth, the transmission bandwidth configuration is set at 90% or 2.7 MHz. Unfortunately, this configuration only allows for a 150 kHz transition band to exist between the LTE-PEBB and B/ILT-CII.

However, if the PEBB proponents were only allowed to operate with a maximum 1.4 MHz LTE channel assignment, then it is possible to offer guard band protection to the incumbent B/ILT and CII users.

A 1.4 MHz LTE signal, with a limited transmission bandwidth of 77% or 1.08 MHz, would provide transition bands of 160 kHz at the top and bottom edges of the transmission bandwidth. In addition, if the 1.4 MHz LTE signal is required to be placed in the middle of the 3x3 MHz PEBB allotment, then a total guard band of 960 kHz[15] is created between the users in the 3x3 MHz and the adjacent 1.85 x 1.85 MHz bands as shown in the figure below. Implementing a guard band by limiting the channel size to 1.4 MHz would help control the amount of OOBE injected into the B/ILT-CII users in the adjacent 900 MHz band and reduce the cost of implementation.

[14] The 550 MHz guard band is calculated by adding 150 kHz the transition band afforded by the 3.0 MHz transmitter + the 400 kHz offered to the Sensus America Inc. application in the 901-902 MHz band that is proposed by PDV.

[15] Guard Band = Transition Band $_{1.4\ \mathrm{MHz\ LTE}}$ + (3.0 MHz-1.4 MHz)/2 = 0.160 + 0.800 = 0.960 MHz or 960 KHz.

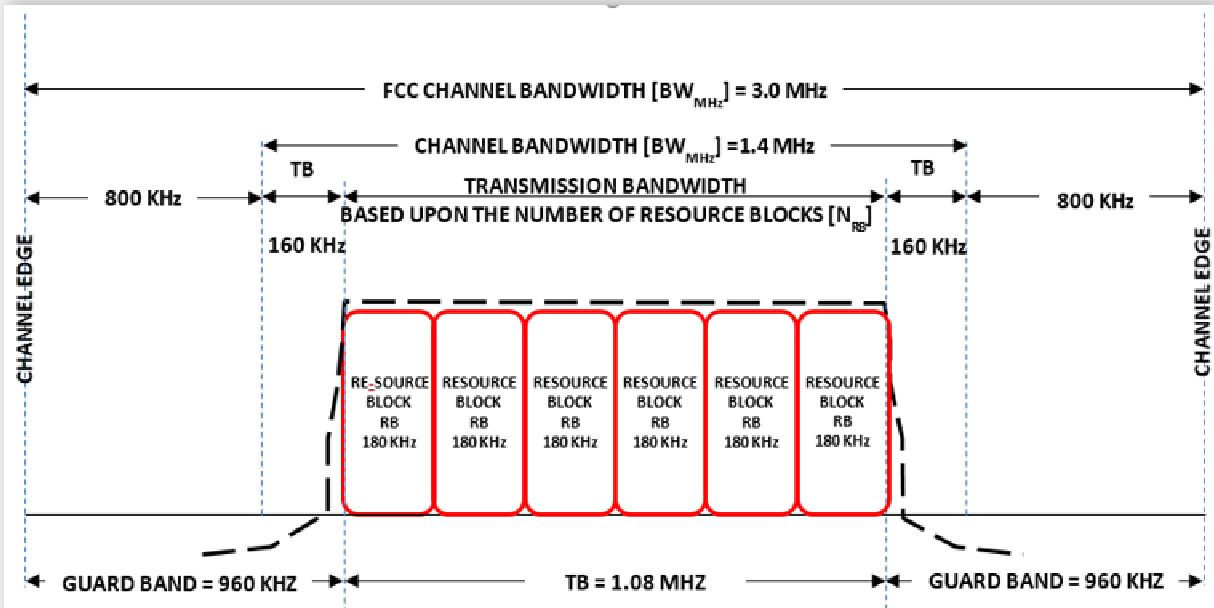


Figure 4: 1.4 MHz LTE with 960 kHz Guard Band

Instantaneous loading of a broadband system directly affects the ERP and active bandwidth of the signal. High levels of activity can be activated by several users in a sector or simply by one user requiring a significant data transfer. These changes may result in flurries of activity at the millisecond level to second time scales affected directly by user activities.

LTE broadband should incorporate a guard band to allow engineering for sufficient OOBE energy to roll off. Using both LTE and B/ILT systems in full or half duplex paired spectrum, with all systems following the same pattern of high/low transmitters vs. subscribers, helps reduce the interference at fixed base stations, but still leaves the mobile or fixed subscriber unit subject to the worst of the situation mentioned above when operating near the other systems transmitters/receivers. Generally, mobile units are not able to utilize external RF filtering to reject harmful interference due to the filter's size. Fixed subscribers may use the RF filtering, but it becomes an increased cost to be borne by the operator of the victim receiver.

An appropriate guard band is an essential buffer that lessens interference in practice and reduces the requirement for large expensive RF mobile receiver filtering.

# 5 Cost to FPL Due to Channel Compaction

Compacting FPL's 900 MHz radio network from a 5 x 5 MHz frequency block into a 1.85 x 1.85 MHz block will cause increased costs to incumbent operators. The projected sources of such costs are summarized below.

## 5.1 Cost of base station locations

The costs incurred include the costs associated with:

- Engineering - System & Site
- Frequency coordination and Re-use Planning
- Licensing – Site based and Geographic
- Antenna Support Structure – Lease or construct
- Antenna & transmission lines
- Equipment shelter – Lease or construct
- Base station or receiver only equipment
- Backhaul requirements
- Base Station controller positions

## 5.2 Cost Associated with Additional Backhaul Services

Additional backhaul services will be required to tie the required new sites into the existing telecommunications network.

## 5.3 Estimated Additional O&M Costs

Estimated operation and maintenance costs associated with the additional sites and backhaul including costs associated with:

- Capital
- Recurring / Operating

The Brattle Group has prepared a Cost-Benefit Analysis ("CBA Report") that accounts for all costs that would be incurred by all of the various impacted parties under the proposed spectrum reallocation.[16] The report specifically uses Florida Power and Light Company assets in performing a "case study" of the effects of the proposal. As provided in Appendix A of the CBA report, FPL's initial reallocation costs are estimated to be nearly $65 million when you consider construction and internal labor costs. In addition, FPL's reoccurring costs for additional leased services is nearly $1.25 million/year. Beyond FPL's individual costs, the CBA report estimates that the EWA/PDV proposal presents a net loss to society between $15 million to $93 million within Florida alone.[17] The CBA report estimates a net benefit to the nation of negative $418 million[18].

[16] The Economics of the 900 MHz Rebanding Proposal, A Cost-Benefit Analysis, prepared by Coleman Bazelon, September 14, 2018, The Brattle Group ("The Brattle Group CBA Report").
[17] See paragraph 80 of The Brattle Group CBA report.
[18] See paragraph 84 of The Brattle Group CBA report.

# 6 800 MHz Rebanding Experience

Operational experience in the 800 MHz band should be leveraged for the creation of any rebanding rules applicable for the 900 MHz band. Real-world practices that are implemented by necessity in the 800 MHz spectrum should be codified to ensure compatibility in 900 MHz.

GP&A investigated industry literature to identify recorded cases where technical coordination, scheduling, and international border issues were encountered with establishing workable channel plans and cutover sequences to complete the re-banding of the 800 MHz band. GP&A examined the level of difficulty to be expected in repacking the existing 900 MHz uses into the 1.85 x 1.85 MHz block of spectrum.

## 6.1 Industry 800 MHz Experience

In 2005, the FCC revealed the original schedule for the 800 MHz reconfiguration. It was an aggressive schedule with an estimated completion in 3 years.

800 MHz re-banding was fairly straight forward in areas with light 800 MHz channel utilization by Public Safety and CII users once frequency plans were engineered for all of the license holders. However, re-banding was more difficult in the highly congested areas and in areas near the Canadian and the Mexican borders.[19] Reallocating the 800 MHz spectrum near the Mexican border took several years longer than planned due to the difficulty encountered in working out the frequency and coordination plans with the Mexico businesses and government.

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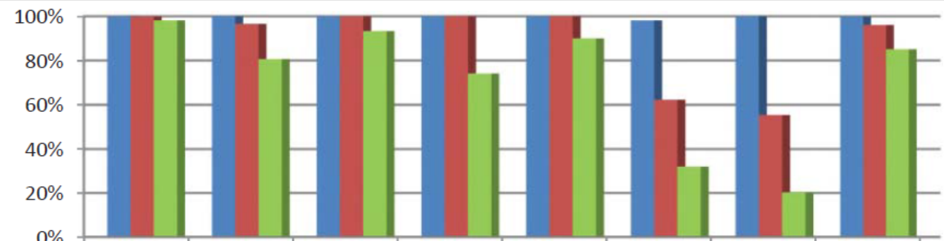
[19] Reference FCC rules in 47 CFR 90.617 Frequencies in the 809.750-824/854.750-869 MHz, and 896-901/935-940 MHz bands available for trunked, conventional or cellular system use in non-border areas. **Reference FCC rules in 47 CFR 90.619 Operations within the U.S./Mexican and U.S./Canada border areas.**

On a national basis, the delays experienced with the 800 MHz conversion in the Canadian and Mexican border areas needs to be considered when deciding whether to attempt a similar process in the 900 MHz band.

### 6.2 Status of 800 MHz Re-banding

In 2018, the 800 MHz reconfigurations have yet to be completed. A report issued by the Transition Administrator (TA) in December 2017 provided an update on the transition schedule as of September 30, 2017. The results are shown in the chart below:

**Chart 1: Status of Negotiations, Physical Retuning, and Closing**




| | Non-border Stage 1 | Non-border Stage 2 | Canadian Border Stage 1 | Canadian Border Stage 2 | Puerto Rico and USVI ESMR | Mexican Border Non-Public Safety | Mexican Border Public Safety | Total |
|---|---|---|---|---|---|---|---|---|
| FRAs Approved | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 98.1% | 100.0% | 99.9% |
| Physical Retune Complete | 99.9% | 96.6% | 100.0% | 100.0% | 100.0% | 62.3% | 55.4% | 96.1% |
| Closing Complete | 98.2% | 80.6% | 93.3% | 74.1% | 90.0% | 32.1% | 20.3% | 85.1% |

As indicated in the chart above the 800 MHz reconfiguration process on a nationwide basis is approximately 85.1% complete. The major delays are completing the Frequency Reconfiguration Agreements (FRA's) with Mexico as well as the installation and physical retuning along the border and non-border areas.

Since the original estimated schedule has exceeded significantly the 3 year projection, with over 13 years to complete the process, a similar schedule needs to be anticipated for the 900 MHz reconfiguration.

### 6.3 700 MHz A Block

Through a combination of bench testing, field tests, and field problem solving by 700 MHz FAN narrowband digital radio manufacturers, system operators, interaction between Verizon and A Block operators and consultants such as GP&A the following lessons have been learned for the 757-758 / 787-788 band:

- Narrowband receiver design has a significant impact on the level of degraded narrowband receiver performance in the presence of adjacent band LTE signals.

- External supplemental filtering is often required for both LTE and narrowband LMR type receivers to co-exist in close proximity to each other. This filtering does add antenna system losses to each system, which reduces coverage from the site for both the LTE and LMR operator, but the negative effects due to the external filtering are less than the unfiltered interference from each system into the other system's receivers.

- Distance between the LTE transmitter and the LMR transmitter has an inverse relationship to the negative impacts of the LTE signal on the narrowband radio receiver and the LMR transmitter on the LTE receiver. Assuming three-sector antennas on the LTE transmitter/receiver and omnidirectional and or sector antennas on the narrowband transmitter/receiver with the transmitter of one system being adjacent band to the receiver of the other system, we note that for the following situations there are several issues that need to be addressed:

    - At 500 feet or less separation

        - Narrowband LMR voice / data receivers will require aggressive external filtering in addition to internal RF and Digital Signal Processing (DSP) filtering to reject the LTE signal and pass the desired narrowband signal to the receiver. No amount of filtering at the narrowband receiver will protect from the LTE OOBE that will be generated from those transmitters. Even with all the protection filtering, proximity will determine much of the energy level in the Narrowband Receiver and may still cause some desensitization (blocking) generated by the LTE transmitter.

- LTE broadband receivers will require external filtering to reject the narrowband LMR voice or data transmitter.

- LTE broadband transmitters will need additional filtering to prevent OOBE interference into LMR receivers.

- LTE broadband should employ a guard band to reduce OOBE.

- At 500-1500 feet separation

  - Narrowband LMR voice / data receivers will require internal RF filtering in addition to the DSP filtering in the Intermediate Frequency (IF) of the receiver to reject the LTE signal and pass the desired narrowband signal to the receiver.

  - LTE receivers will require internal RF filtering in addition to the DSP filtering in the IF or other signal levels of the receiver to reject the LMR voice / data signal and pass the desired narrowband signal to the receiver.

  - LTE broadband receivers may require external filtering to reject the narrowband LMR voice or data transmitter.

  - LTE broadband transmitters will need additional transmitter filtering to prevent OOBE interference into LMR receivers.

  - LTE broadband should employ a guard band to reduce OOBE.

- At 2500 feet and more separation

- Narrowband LMR voice / data receivers will require advanced DSP filtering in the IF of the receiver to reject the LTE signal and pass the desired narrowband signal to the receiver.

- LMR receivers with advanced DSP filtering in the IF of the receiver to reject the Narrowband LMR voice / data signal appear to operate without degradation.

- LTE broadband receivers may require external filtering to reject the narrowband LMR voice or data transmitter.

- LTE broadband transmitters may need additional transmitter filtering to prevent OOBE interference into LMR receivers.

# 7 Narrowband Internet of Things (IoT) is More in Line with CII Requirements

Although utilities need access to broadband services, many IoT and machine-to-machine applications that will be useful to CII entities are not inherently broadband in nature. In fact, the trend in LTE standards for IoT functions is to define smaller bandwidths (i.e., NB-IoT). Using more bandwidth than needed is inefficient in terms of spectrum use and harmful in terms of the narrowband systems that are potentially displaced.

Push-to-talk and real-time voice communications in a CII application are not services that broadband LTE was designed to serve in a cost-effective efficient manner. Instead, LTE was designed for larger capacity data transfer rates rather than coverage.

Many of the low speed data applications, such as Distribution Automation (DA), can be inexpensively monitored and controlled over a very low data capacity link that piggybacks onto various voice radio networks with high reliability. Many of FPL's DA applications are located in remote locations, where it is not economically feasible to add a PEBB LTE network to serve the low bandwidth DA applications identified below.

- Remotely located capacitor banks

Capacitor banks are primarily used to improve the power factor in the network. They also improve the voltage stability and reduce network losses. Improving the power factor translates to more efficient power delivery. It is estimated that FPL's existing Capacitor Bank system provides efficiency gains that eliminate the need for up to two additional power plants.

Typical capacitor bank monitoring and control systems require 60 bytes for queries and about 60 to 320 bytes of data uploaded using report-by-exception protocol, reporting only when a significant change in voltage is detected. Remote switching of the capacitor bank by dispatcher intervention is initiated by a voltage monitoring event, followed by a control command and a return of the switch status and line voltage. Typically the time delay between a dispatcher initiated control and a feedback of the line voltage and switch position indication is less than 10 - 20 seconds, which is well within the response time provided by P25 trunked radio systems.

- Motorized line switches

The current coverage footprint of FPL's narrowband system is well suited to communicate with remote feeder control switches that are used to isolate outages and recover electrical service to the maximum number of homes and businesses.

Due to the limited amount of communications required to monitor and operate feeder switches combined with the extended range of 900 MHz LMR sites, FPL's existing narrowband system provides an efficient option for this function.

The cost to implement the broadband service to address this requirement would be price prohibitive due to the limited range of broadband service, and will be spectrally inefficient because these services do not require large amounts of data in short amounts of time.

- Feeder Line Voltage and Current Monitors

Feeder Voltage Monitors and Current Ratio Monitors are devices that are connected directly to transmission or major distribution lines that leave or enter transmission and distribution substations. Feeder voltage and current ratio devices have approximately 20-50 kb of data per transfer and only report on demand or when a percentage of change is exceeded.

- Distribution Line Voltage Monitors

A Line Voltage Monitor is a voltage monitoring device that is connected to a main distribution or branching section line that has a data requirement of 20-40 bytes and are polled every 15 minutes. The uplink from the remote device uses report-by-exception and only sends data when a line voltage level has changed more than a programmed percentage threshold.

FPL expects to incorporate approximately 5,000 Distribution Line Voltage Monitoring (DLVM) units by the year 2028.[20] The DLVM units will be deployed and connected to 124 P25 base stations within FPL's service area. On the average, each P25 base station would have approximately 40 remote DLVM's requiring an average of about 20 bps data transfer rate to support the application.

- Distributed Generation Systems

Distribution generation systems allow energy distribution from home to the grid during times of high demand. Examples of distributed generation systems include storage battery systems that shave the cost of peak use times by co-generating their own power to reduce cost during peak use times.

The typical amount of data that is transferred during a query can be up to 60 bytes for queries and about 60 to 320 bytes per response from the remote unit. The remote units will use report-by-exception protocol to limit the need to communicate until a value changes beyond a specified threshold.

Additionally, as consumers implement more systems like rooftop solar there is the need to monitor these systems and to identify their impact on the grid. FPL estimates that for the state of Florida, there will be up to 1 M residential and 0.5 M commercial distributed generation systems by 2028. The data load from the total number of residential and commercial systems will be spread over FPL's 123 P25 base station sites. The remote DGS units will be polled once every 24 hours. The average data rate is expected to be less than 0.80 kbps per P25 base station.

FPL plans to use their P25 trunked radio system as a backup to their Field Area Networks and SCADA radios so the amount of loading on the P25 system is expected to be very low.

[20] This is estimate is based upon FPL's 10 year projection.

Changing weather conditions can create volatility conditions that the serving utility must react to in real time. The data requirements of this communication are limited, but must be served by a system designed with mission critical reliability like utility LMR systems.

The rebanding of 900 MHz into the 1.85 x 1.85 MHz band will restrict the coverage available to FPL and potentially place the reliability of LMR system at risk. In contrast, the broadband applications to be offered by a PEBB are limited in power and range so they cannot compete for the low speed data applications used by CII in rural sparsely populated areas.

## 8 Regarding EWA/PDV proposed Rule Changes

In EWA/PDV's November 1, 2017 Reply Comments[21] (reference page 14), EWA/PDV is proposing an established minimum receive signal be the determining factor to be considered when evaluating whether an interference claim can be filed. EWA/PDV proposed a Rule Section 90.1421, Interference Protection Rights, which would set signal strength standards of -98 dBm for mobiles and -95 dBm for portables as a threshold for making an interference claim."

Signal strength protection level standards should be set at -104 dBm for mobiles and -101 dBm for portables which matches levels currently for the 800 MHz band in 47 CFR Section 90.672

FPL's existing 900 MHz narrowband radio system operates in an average base station site noise environment with 0 to 2 dB of receiver sensitivity degradation. The coverage analysis provided in the Appendix A, projects the impact of a 14 dB noise degradation on FPL's 900 MHz radio system and the resulting prediction of coverage reduction. Table 3 summarizes the impacts on the major FPL service areas.

[21] REPLY COMMENTS OF ENTERPRISE WIRELESS ALLIANCE AND PDV WIRELISE, In the Matter of: Review of the Commission's Rules Governing WT Docket No. 17-200, *Notice of Inquiry*, 32 FCC Rcd 6421(2017) ("NOI").

Table 3: Predicted RF Coverage Reduction of FPL Service Areas

| Service Area | % Area Covered @ DAQ 3.4/5% BER RSL >=-110 dBm (Present Coverage) | % Area Covered @ DAQ 3.4 / 5% BER RSL>=-96 dBm (14 dB C/(I+N)) | % Area Covered @ DAQ 3.4 / 5% BER RSL>=-87 dBm (18 dB C/(I+N)) | Reduction of DAQ 3.4 Coverage Area @ -96 dBm | Reduction of DAQ 3.4 Coverage Area @ -87 dBm |
|---|---|---|---|---|---|
| Boca Raton | 98.1% | 73.0% | 33.8% | 19.1% | 64.3% |
| Brevard | 98.3% | 76.7% | 47.5% | 21.6% | 50.8% |
| Central Dade | 100.0% | 99.9% | 97.5% | 0.1% | 2.5% |
| Central Florida | 97.0% | 69.5% | 32.4% | 27.5% | 64.6% |
| Gulfstream | 100.0% | 99.4% | 74.3% | 0.6% | 25.7% |
| Manasota | 98.9% | 81.0% | 47.2% | 17.9% | 51.7% |
| Naples | 100.0% | 87.0% | 46.0% | 13.0% | 54.0% |
| North Florida | 99.0% | 69.9% | 35.1% | 29.1% | 63.9% |
| Northeast | 100.0% | 99.5% | 71.3% | 0.5% | 28.7% |
| Pompano | 100.0% | 96.4% | 47.1% | 3.6% | 52.9% |
| South Dade | 99.3% | 78.6% | 52.7% | 20.7% | 46.6% |
| Toledo Blade | 97.9% | 74.1% | 34.7% | 23.8% | 63.2% |
| Treasure Coast | 97.5% | 71.7% | 35.3% | 25.8% | 62.2% |
| West Dade | 99.6% | 88.4% | 50.4% | 11.2% | 49.2% |
| West Palm | 100.0% | 88.4% | 38.0% | 11.6% | 62.0% |
| Wingate | 100.0% | 99.9% | 85.3% | 0.10% | 14.7% |

Although it is hard to predict the actual impact on FPL's existing 900 MHz system caused by relocating to the 1.85 x 1.85 MHz band, the proposed 47 C.F.R. 90.1412 rule should be modified to the same protection levels given to the 800 MHz service. The protection levels should be changed to:

1. Talk Out Base to Mobile: RSL >= -104 dBm
2. Talk Out Base to Portable: RSL >= -101 dBm

Protection limitation thresholds as defined in Section 90.672 of the FCC's Rules constrain protections and allow out-of-band operators to generate interference within the narrowband allocation. As a practical matter these thresholds are cumbersome to use. First the interference must be identified. In practice several incidents may occur before users identify an area subject to unreliable communication. Commonly, a field user may report failed communications either during routine or emergency operations. Once an area appears to have recurring issues, other personnel capable of assessing the issue must visit the location and attempt to re-create the issue. Frequently, even this step can be challenging because broadband systems create much higher levels of interference during heavy loading situations that may be associated with an incident, time-of-day, or current adaptive parameters. Follow up testing at the same location may not show the same level of interference when tests are performed at the same location. Therefore, multiple evaluations over time including differing parts of the day may be required to establish when harmful interference is occurring.

Once the interference is detected, detailed measurements in the vicinity are necessary to establish a median signal level to compare against the protection threshold. At this point the owner of the interfering system is contacted and a measurement/ mitigation process can begin governed by Commission rules in Sections 90.672 – 90.674. This process can work for rare events with static communication systems. However, broadband communication systems are not static. These systems vary their transmission statistics in a range of time scales.

# 9 APPENDIX A - Coverage Analysis

Coverage Analysis of a Portion of FPL's 900 MHz Trunked Radio Network

Harris, one of FPL's equipment vendors, conducted a preliminary coverage analysis on a portion of the FPL's 900 MHz radio network to analyze the impact from the proposed PEBB LTE network. The increased noise level and interference is assumed to be caused by the addition of more channels into a limited 1.85 x 1.85 MHz band allotment. Increasing the noise level reduces coverage area. Reducing signal level to avoid interference also reduces coverage.

The study incorporated a total of 17 sites in FPL's North Florida management area and included coverage studies which predicted reduced coverage area due the additional noise added to FPL's sites.

FPL's current system is built to a design objective of meeting a receiver sensitivity level of -110 dBm. PDV's proposed rule change would provide interference protection for areas covered with a receive signal level of -98 dBm for mobiles and -95 dBm for portables. Based on the PDV proposal, the expected interference level will be somewhere between 12 dB and 15 dB higher than the current design objective. The analysis used a C/(I+N) objective of 14 dB in order to evaluate the impact that a 12 to 15 dB degradation will have on coverage area, and predicts the number of sites added to recapture coverage would increase by 12 sites or by 170%.

Using the same ratio (170%) and applying it to the FPL's existing 67 site trunked radio systems (including the two (2) Nuclear Plant Siren radio systems) at least an additional 46 sites were determined necessary to recapture the trunked radio coverage assuming a C/(I+N) ratio of 14 dB. The number of predicted new sites was rounded to 45 because this initial analysis is not of sufficient certainty to assume that it can precisely predict the number of additional sites needed to replicate coverage. The actual number of sites required may be higher, and would need to be determined based on a channel plan that accounts for all narrowband users that would be required to relocate into the

1.85 x 1.85 MHz of spectrum. Another 11 sites were added to account for the potential degradation from adjacent channel interference from other users outside of FPL systems. A total of 56 new sites were added to recapture FPL's coverage.

Elevated noise floor, -105 dBm

Empirical data shows that the majority of FPL's RF sites are not currently experiencing coverage degradation due to receiver sensitivity degradation from their environments. Typical site sensitivity degradation is currently in the 0-2 dB range with a measured noise floor of -119 dBm. If the noise floor in the system is elevated to -105 dBm (a difference of 14 dB), then system performance will degrade significantly.

The table below shows the difference in predicted covered area between the current specification (-110 dBm) and 14 dB down (-96 dBm). In fact, depending on the nature of the interference waveform, a P25 phase 2 waveform requires 16-18 dB of carrier/interference (C/I) for a voice quality of DAQ 3.4. The worst-case assumption would be that 18 dB of C/I is needed above the new interference source of -105 dBm, which is also included in the analysis below (-105 + 18 = -87 dBm).

| Boundary | ≥ –110 | ≥ –96 | ≥ –87 |
|---|---|---|---|
| Florida | 48.2% | 30.7% | 16.1% |
| Pipeline_1mile | 58.3% | 32.1% | 14.8% |
| Boca_Raton | 98.1% | 73.0% | 33.8% |
| Brevard | 98.3% | 76.7% | 47.5% |
| Central_Dade | 100.0% | 99.9% | 97.5% |
| Central_Florida | 97.0% | 69.5% | 32.4% |
| Gulfstream | 100.0% | 99.4% | 74.3% |
| Manasota | 98.9% | 81.0% | 47.2% |
| Naples | 100.0% | 87.1% | 46.0% |
| North_Florida | 99.0% | 69.9% | 35.1% |
| Northeast | 100.0% | 99.5% | 71.3% |
| Pompano | 100.0% | 96.4% | 47.1% |
| South_Dade | 99.3% | 78.6% | 52.7% |
| Toledo_Blade | 97.9% | 74.1% | 34.7% |
| Treasure_Coast | 97.5% | 71.7% | 35.3% |
| West_Dade | 99.6% | 88.4% | 50.4% |
| West_Palm | 100.0% | 88.4% | 38.0% |
| Wingate | 100.0% | 99.9% | 85.3% |

In either of these cases, to reach the objective of 95% portable coverage, a significant number of RF sites would need to be added. As an example, the coverage map for the North Florida management area at -96 dBm is shown below. In order to fix this problem, it is estimated that at least 12 RF sites would need to be added to the 17 existing.

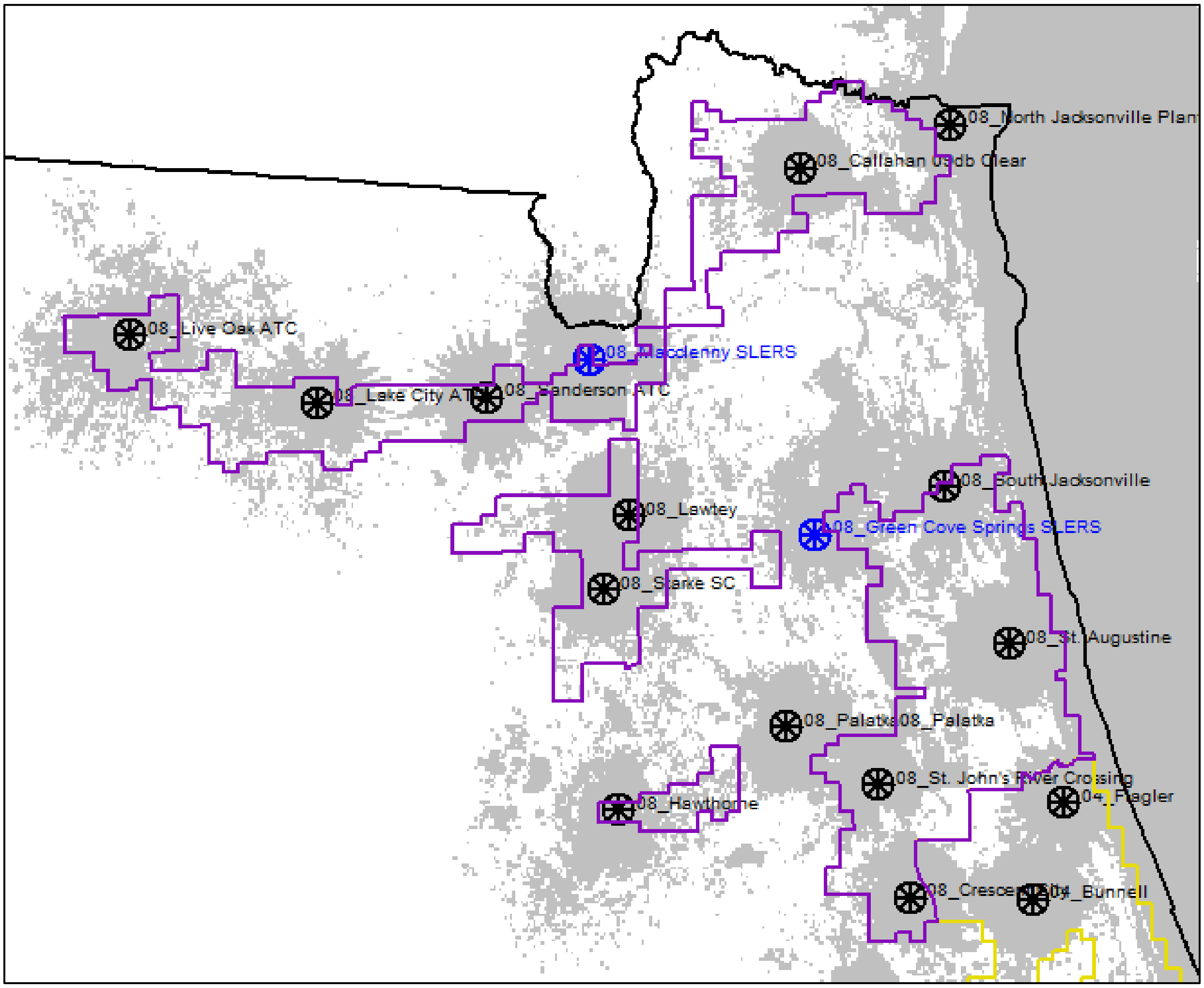



Figure 5: Coverage Analysis 17 Site Study @ -96 dBm

## Additional destructive frequency interference

There are a significant number of co-channel frequency reuse in FPL's system today. Analysis shows that in the Florida environment, there is destructive interference with up to 10% of the coverage footprint within 60 miles and 5% up to 90 miles. With the compression of the 900 MHz band, FPL may be forced to plan for more frequency reuse. There are currently 131 instances of co-channel frequency reuse within 90 miles

(615 instances total at any distance). Although this cannot be quantified precisely without a new frequency plan, greater frequency reuse at shorter distances will be required.

Transmitter power loss through hybrid combiners

In the current P25 system design, combiner loss has been limited to 2.8 dB by keeping channel spacing at every RF site to over 500 kHz and by using multiple TX antennas per site (3 channel max per antenna). The P25 system loss budget assumes this in the coverage analysis and balances the talk-out and talk-back radio performance without artificially reducing the coverage footprint. To keep the maximum coverage performance with tighter channel spacing (and more combiner loss), FPL would either have to increase transmitter power or add TX antennas. The average P25 TX power level of RF sites is currently 49 dBm. Based on this, on average, FPL will only be able to make up for 1db of additional combiner loss. At most of FPL's RF sites, additional antennas will likely be necessary.

Mobile radio receiver sensitivity degradation near interfering sites

There is the possibility of mobile radio receiver desensitization near high-power LTE transmitter sites. Although FPL is using radio receivers designed to optimally minimize desensitization from nearby strong transmitters, this could still happen in areas where the P25 signal level is not strong.